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napevomo?

SUSTAINABLE SOLAR HOUSE

# Engineering and construction

## Brief report

ARTS ET MÉTIERS PARISTECH TEAM
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# Engineering brief report

## 1. Project's genesis and objectives definition

Engineering design of Napevomo is the result of co-conception process between engineering and architecture students. Primary objectives helped define a common goal for the design team: to build a house with a low environmental impact on most aspects of its whole life cycle.

Considering the local availability of a sustainable construction material, timber, choosing this carbon neutral material was rather obvious, even though this choice had to be justified via a proper life cycle analysis, which would be the next step. Apart from this particular choice, primary objectives were defined with numbers based on French references such as summer comfort (degree-day) or low consumption buildings (BBC certificate) which gave us targets to reach energy performance and comfort.

## 2. Pre-design stage and feasibility study

In the pre-design stage we explored all sorts of constructive solutions and translated our targets into physical parameters such as U-values and thermal capacities. It was also the stage to analyze relevant combinations of energy systems (i.e. to produce energy and to provide heat and coolness).

### Constructive solutions and insulation

Following our primary objective to use a maximum of local materials, we looked for designing a 100% made in Aquitaine house. The maritime pine from the Landes forest has been selected to promote a new lengthening process that uses green wood (not dried out) to make glulam beams. This new technique allows to reduce embodied energy of the final product and enhances mechanical properties compared to conventional glulams.

Insulation material is also produced from wood-based resources, such as sawmill waste for the wood fiber panels (in walls) and recycled newspapers for the cellulose wadding (in the roof and the floor).

### Assembly solutions

Transportation of our prototype had to be optimized in order to limit related CO2 emissions and embodied energy of the house. So, we looked for an assembly solution which would meanwhile make transport and assembly easy. This is why we selected elements so that can easily be put on lorries and occupy a minimum volume to limit the number of trucks.

## HVAC and energy management strategy

The energy management strategy was essential to guaranty high performances of the whole prototype. Energy production systems had to be found with regards to the needs in the most efficient way.

The first strategy was to maximize the use of solar hot water, which can be produced with a higher yield than photovoltaic cells. Therefore systems were chosen to directly heat the air with solar water. To be effective, we chose to be compact, using a minimum number of systems. HVAC would thus work via the air.

As the need for coolness is very important in Madrid, we had to make great efforts to cool the interior in summer. For this particular need, we developed a passive cooling system based on phase change materials. These materials were put in a heat exchanger to maximize heat transfer and make the best use of their cooling potential. This system was a specific project led in one of the school's laboratories (Trefle).

## Water management

The aim of Napevomo's water management was to recreate a natural water cycle within the house, in order to reduce fresh water consumption and grey water rejections. A natural grey water treatment allows to reuse it to irrigate the green roof and wall.

## Building automation control system

Building automation control system (BACs) is not only a tool to bring comfort in everyday life. It is also a means to prevent energy waste and make the best use of complex technologies. In this way we chose a BACs with relevant components and programs.

## Energy production

To produce most useful energy as possible from a limited area, we looked at common heat and power generation systems. A solution was found with a solar concentrator that a local engineering company wanted to develop with our team. This system eventually increases energy yield and reduces embodied energy because it uses less silicon than for an equivalent conventional PV panel.

# 3. Advanced design stage

In the advanced design stage we validated our strategies and parameters via dynamic thermal simulations. It was the stage for optimizing our prototype. Different wall compositions were tested. Thickness of insulation, size of openings, every architectural element has been precisely defined with regards to its impact on the thermal behavior of the house and comfort conditions.

In this phase we also designed the whole structure and technical networks via a 3D CAD software, in order to anticipate problems that could occur in such a small volume that integrates a lot of equipments.